

Remarks

Claims 5-9, 11 and 13-16 are pending in the above-identified patent application. With this response, claims 7 and 11 have been amended. No other claims are canceled or added.

Claim 7 and 11 have been amended for purposes of clarification. Support is found at page 4, lines 11-13.

Applicants respectfully request reconsideration and further examination of the application in view of the amendments above and remarks below.

Rejection Under 35 U.S.C. §103

Claims 8, 9, 5, 6 and 13-16 are rejected under 35 U.S.C. §103(a) as being unpatentable over Chakravarti et al. (U.S. Patent No. 6,497,852), in view of Ronning et al. (U.S. Patent No. 5,832,712).

The Office Action asserts that it would be obvious to use the temperature regime of Ronning in the Chakravarti system in order to arrive at the subject matter of the claims. This rejection is traversed in that negative teachings in Chakravarti make it improper to combine Chakravarti and Ronning in the proposed manner. Ronning further expressly limits its temperature conditions to an experiment of short duration in view of expected amine degradation, further demonstrating that nothing in Ronning supports the proposed combination in the context of Chakravarti's system intended for long-term operation.

In more detail, the present invention is in the field of high pressure recovery of acid gas such as CO₂ from raw gas streams contaminated with undue acid gas content. In a typical mode of practice, a contaminated raw gas is caused to contact an absorbing fluid. This causes transfer of the acid gas contaminants from the raw gas to the absorbing liquid via mass transfer. As a result of the contact, the raw gas becomes purified. In the meantime, the absorbing liquid becomes laden with the acid gas material(s) picked up from the raw gas. The absorbing liquid carrying the acid gases removed from the raw gas and is said to be "rich" with respect to acid gas at this stage. The rich absorbing liquid is then regenerated by stripping the acid gas content in additional mass transfer operation(s). The regenerated liquid can then be fed back to the absorbing tower. The stripped acid gas also is recovered for disposal, further handling, etc. For example, it is desirable in many instances to recover CO₂ under high pressure.

The capital and operating costs of such an absorber/regeneration system are quite high. Therefore, there is a strong demand in industry to develop strategies that reduce the capital and operating costs associated with these systems.

The present invention addresses this problem. The present invention provides a technical solution that helps make the regeneration aspects more efficient and economical. The technical solution of the invention involves regenerating the rich absorbing liquid under both elevated pressure and elevated temperature. These conditions drive the acid gas(es) from the absorbing liquid into a vapor phase. The pressure on the vapor phase maintained until the acid gas is further compressed in one or more compression stages that are downstream from the unit in which the stripping is carried out.

Surprisingly, the present inventors have discovered that using both higher pressure and higher temperature in the regeneration system and then maintaining that pressure on the gas leaving the regeneration stage requires less energy input to recover high pressure acid gas! In other words, even though higher pressures and higher temperatures are used at the regeneration stage, the process as a whole is more efficient and economical. This is quite counterintuitive. One would expect operating costs to increase when both temperature and pressure are increased.

The unexpected result is shown in Table 1 of the present specification. The Table lists characteristics of three samples. Example A is a comparative that used low pressures (conventional approach) for regeneration. The values for lean heat exchanger duty, reflux cooler duty, reboiler duty, total cooling, and compressor duty for Example A indicate the main energy burden for achieving regeneration. The total compression horsepower required to recover exemplary high pressure CO₂ is reported as 787 hp.

Examples 1 and 2 show the same kind of information for two exemplary embodiments of the present invention. Please refer to the required compression horsepower needed to recover high pressure CO₂ for these two samples. Whereas comparative Example A required 787 hp total compression to achieve the final desired compression, Examples 1 and 2 required only 618 hp and 406 hp, respectively.

It is true that, even though compression requirements dropped significantly for Examples 1 and 2 relative to Example A, the heat exchanger requirements are higher for Examples 1 and 2. In practical effect, what this means is that more of the energy burden of recovering high pressure

acid gas has been shifted from compression operations to heat exchanger operations. But if the demand placed upon heat exchanger operations has increased, how is there any efficiency and economic gains? Heat exchanger operations generally are substantially less expensive than compression operations. See Para. 38 of the present specification. Consequently, use of the present invention allows more cost effective regeneration and subsequent handling of acid gases such as CO₂.

With this understanding, the differences between the claimed invention and the cited documents are clearer as will now be discussed.

The Office Action recognizes that Chakravarti fails to teach the claimed temperature regime. To allegedly cure this deficiency, the Office Action states that it would be obvious to use the temperature regime of Ronning in the system of Chakravarti to arrive at the claimed subject matter. This rejection is respectfully traversed.

Chakravarti expressly instructs the skilled worker that bottom temperatures in the stripping stage can be as high as 135°C (275°F), but that the skilled worker must practice care "to ensure that the temperature does not exceed much beyond 140°C [284°F]." See col. 3, line 66 to col. 4, line 11. Chakravarti warns in these same passages that exceeding this temperature range degrades the amines, undermining process performance. These express negative teachings cause the skilled worker to avoid using temperatures much over 140°C.

Ronning does not provide motivation for a skilled worker to ignore the negative teachings of Chakravarti. In fact, Ronning expressly qualifies its use of higher temperatures in a way that reinforces the negative teachings of Chakravarti, making those negative teachings even stronger in the eyes of the skilled worker. Although true that Ronning suggests using a temperature range of 120°C to 150°C for stripping, Ronning explains the limited circumstances that make the higher temperature regime tolerable to Ronning. At col. 4, lines 64-67 [Emphasis added in the following quoted passage], Ronning explains that "Degradation of the absorption chemical 18 will occur due to the formation of heat stable salts and other short chain compounds. These contaminants are removed from the MEA purification unit which is in operation for only a short time." Reading this passage in the context of Ronning as a whole, the degradation caused by high temperatures is acceptable because Ronning is conducting a short-term experiment.

It is not seen how Ronning's acceptance of temperature degradation as a short term risk makes it obvious to use the Ronning temperature conditions in the Chakravarti system that is intended for long term operation. Chakravarti is just as aware of the degradation risks and makes the different choice that, in the different context of the Chakravarti system intended for long term operation, the temperature must not exceed much beyond 140°C. The fact that Ronning accepted degradation risks in the context of a short term experiment is not sufficient to overcome the express negative teachings of Chakravarti in the different context of Chakravarti's system intended for long term operation.

Indeed, by accepting degradation risk solely on the basis that the risks are tolerable in the context of a short term experiment, Ronning actually reinforces the need to avoid degradation risk in a system like Chakravarti's that is intended for long term operation. Rather than overcome the negative teachings of Chakravarti, Ronning makes them stronger and more poignant. Therefore, nothing in Ronning, when properly construed and read as a whole, makes it obvious to use high temperatures in the Chakravarti system.

In view of these remarks, it is respectfully submitted that the rejected claims are patentable over the proposed combination of Chakravarti et al. and Ronning et al. Withdrawal of the rejection is respectfully requested.

Claims 7 and 11 are rejected under 35 U.S.C. §103(a) as being unpatentable over Chakravarti et al. (U.S. Patent No. 6,497,852), in view of Iijima et al. (JP 10-067994) and Ronning et al. (U.S. Patent No. 5,832,712).

This rejection is respectfully traversed. Even if the solvent features of Iijima were to be of interest in the Chakravarti system via hindsight reconstruction, the proposed combination still fails to cure the significant deficiencies of the proposed combination of Chakravarti with Ronning. As discussed above, Ronning fails to make it obvious to use high temperature conditions in the Chakravarti system.

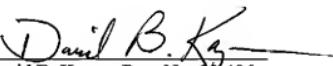
Inasmuch as Iijima fails to cure the Chakravarti/Ronning deficiencies, it is respectfully submitted that the rejected claims are patentable over the proposed combination of Chakravarti et al., Iijima et al and Ronning et al. Withdrawal of the rejection is respectfully requested.

Conclusion

In view of the above election and remarks, Applicants submit that the foregoing is fully responsive to the outstanding Office Action. In the event that a phone conference between the Examiner and the Applicants' undersigned attorney would help resolve any issues in the application, the Examiner is invited to contact said attorney at (651) 275-9804.

Respectfully Submitted,

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